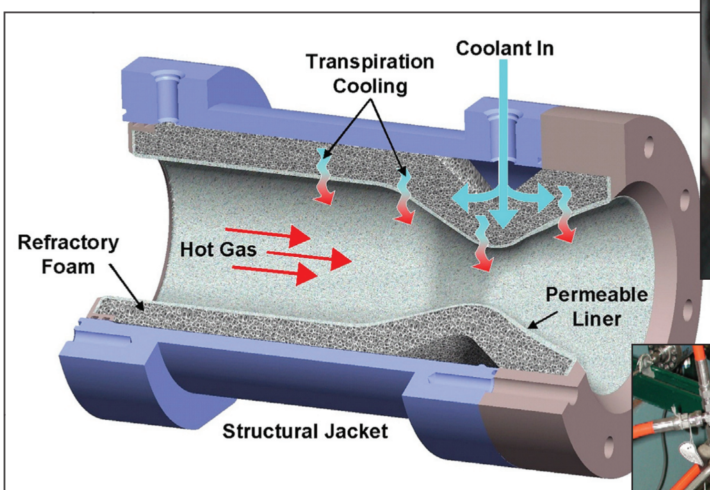
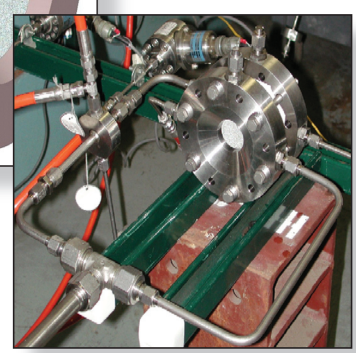
Air Force Research Laboratory | AFRL

Science and Technology for Tomorrow's Air and Space Force

Success Story

RESEARCHERS DEVELOP TRANSPIRATION-COOLING CONCEPT TO REDUCE WEIGHT AND IMPROVE PERFORMANCE OF ROCKET ENGINE THRUST CHAMBERS





The Materials and Manufacturing Directorate developed a transpiration-cooled thrust chamber concept as part of the Integrated High Payoff Rocket Propulsion Technology (IHPRPT) program. This concept consists of three major parts: a porous inner liner, an intermediate foam coolant plenum, and an outer structural jacket.

Researchers expect this new technology to reduce the weight of current, actively cooled thrust chambers by 50% and significantly reduce system complexity, part count, cost, and coolant volume. Reducing the weight of rocket engines will enable increased payloads, potentially saving millions of dollars in launch costs.

Air Force Research Laboratory
Wright-Patterson AFB OH

Accomplishment

Scientists and engineers conducting research for the directorate partnered with Ultramet, a small business in Pacoima, California, to develop and demonstrate transpiration-cooling concepts and materials that could lead to lightweight, high-efficiency combustion chambers for rocket engines. By replacing conventional cooling concepts and materials with lightweight ceramic or metallic foams coated with a porous transpiring ceramic or metallic liner, researchers expect to reduce the weight and cost of future liquid-fueled rocket engines.

Background

In a liquid-fueled rocket engine such as the Space Shuttle Main Engine, the engine injects a fuel (in this case, liquid hydrogen) and an oxidizer (liquid oxygen) into a thrust chamber where they mix and react. The fuel/oxidizer reaction products are high-temperature gases, which expand through a nozzle, producing thrust.

Combustion takes place at temperatures in excess of 6,000° F, which is higher than the melting point of conventional engine materials. Therefore, the engine must cool the chamber materials with the continuous flow of a fluid that carries heat away from the chamber walls. In this case, the hydrogen fuel also serves as the coolant fluid.

Current state-of-the-art thrust chambers are comprised of an inner copper liner with machined cooling channels, a thin layer of nickel to close out the channels, and an outer nickel-based alloy structural jacket. During operation, the engine pumps hydrogen coolant through the channels in the copper liner to keep it from melting. The current thrust chambers are heavy, complex, and expensive, and require large amounts of cooling.

Researchers collaborating as part of this IHPRPT program expect to demonstrate a combustion chamber concept using high-temperature materials and transpiration-cooling methods that can significantly improve performance while reducing weight and cost. The transpiration-cooled thrust chamber concept consists of a porous inner liner, an intermediate foam core, and an outer jacket for structural support.

Advances in propulsion, achieved during this effort, will advance the goals of the IHPRPT program. The program will improve the nation's capability to move into full-scale development of rocket propulsion systems with improved performance, affordability, operability, reliability, and maintainability.

Materials and Manufacturing
Emerging Technologies

Additional information

To receive more information about this or other activities in the Air Force Research Laboratory, contact TECH CONNECT, AFRL/XPTC, (800) 203-6451 and you will be directed to the appropriate laboratory expert. (04-ML-09)